What is the Best Renewable Energy Source?

Angela Cui

Abstract

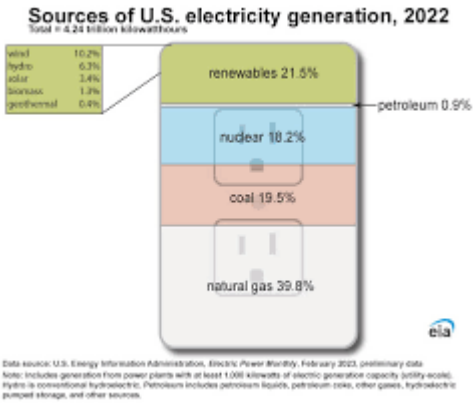
As the global supply of fossil fuels becomes more and more limited and the urgency to address climate change becomes more critical, renewable energy sources like wind energy, solar energy, biomass, geothermal and hydropower become important alternatives. In this paper, we will be discussing the current use and future potential of these energy sources in the United States. Despite renewables contributing only 20% of the nation's electricity in 2022, their role is expanding, with solar and wind energy expected to see substantial growth by 2025. Each energy source offers distinct benefits: wind energy provides substantial electricity with minimal operational costs, hydropower ensures reliable and emission-free power, solar energy promises significant reductions in greenhouse gasses and improves air quality, biomass supports local economies and waste reduction, and geothermal energy offers a stable and low-emission power source. However, these sources also face challenges, including land use conflicts, high initial costs, environmental impacts, and technological limitations. By examining these factors, the paper aims to assess which renewable energy source holds the most promise for a sustainable energy future and how best to integrate and optimize these resources to achieve long-term environmental and economic goals.

Introduction

Currently, the limited supply of fossil fuels is depleting and there is an increased urgency to reduce carbon emissions. In come renewable energy sources like solar energy, wind energy, hydropower, geothermal, and biomass all are important alternatives to the use of fossil fuels, each with unique attributes and characteristics. But which one of these holds the biggest promise for a sustainable future? In this paper we will examine the aspects of each source, along with its advantages and challenges.

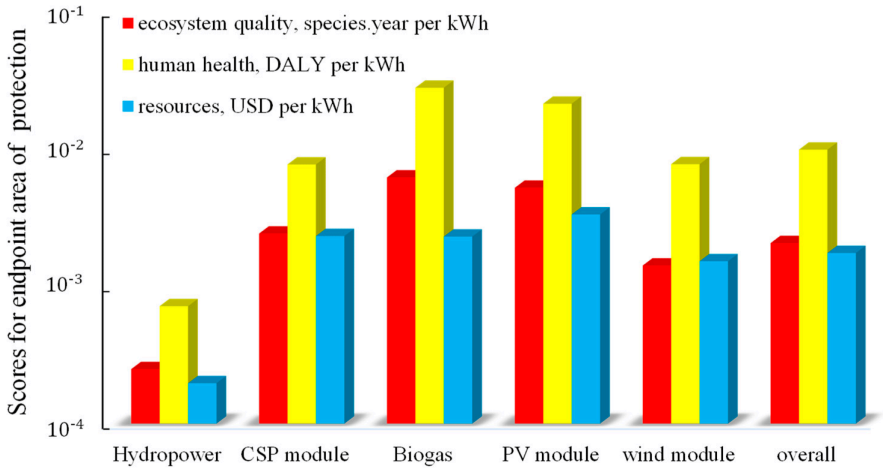
Current State of Renewable Energy

As of right now, power generation is still mainly dominated by fossil fuels. The image to the right shows the sources of US electricity generation in 2022. Based on the graph, we can see that renewable energy sources only generated about 20% of electricity in the US in 2022, which is not a lot. However, as the supply of fossil fuels keeps decreasing, the use of renewable energy will conversely increase. According to the U.S. Energy Information Administration (2023), “solar power will grow [by] 75%”, and wind by 11% in the US by 2025 (U.S. Energy Information Administration, 2023). Currently in the lead is wind energy supplying 10.3% of electricity generated, followed by hydropower, solar, biomass, and lastly geothermal, only supplying around 0.4% of electricity.



Benefits of Renewable Energy

Why does renewable energy have an advantage over fossil fuels? This is because these energy sources offer many benefits, including the mitigation and reduction of carbon emissions into the air and in turn slowing down global warming, decreasing the reliance on limited supply fossil fuels, and generating energy with multiple sources. They also create job opportunities in new industries, promote sustainable development, and reduce pollution both in the air and in water, leading to better public health. Renewable energy sources are abundant and sustainable, which provide a long term solution for meeting the world's increasing use of energy. Below is an image that shows how renewable energy sources improve overall public health, ecosystem health, as well as increase the supply of resources.



Wind

Wind energy is an unlimited renewable energy that uses the power of wind to drive turbines, generating energy.. Currently, it supplies the most electricity compared to all the other sources and by 2050, it could supply one-third of the United States' electricity, providing a significant reduction in greenhouse gas emissions and promoting energy self sufficiency. Wind energy has many benefits. Firstly , it is basically an infinite resource that can be collected without taking away any natural resources around it. Using wind energy also generates electricity without using fossil fuels which reduces both carbon emissions as well as reliance on fossil fuels in the future. The wind energy sector creates jobs in many different areas like research, manufacturing, construction, operation, etc. After installation of the wind turbines, the costs to operate and maintain the turbine are pretty low compared to power plants. Although there are numerous pros, there are also cons associated with wind energy. Wind energy changes and generates depending on the weather conditions of the day, so a strong dependence on wind energy may be risky if the wind is low on a particular day. Wind farms require a lot of land, as well as other appliances that can help generate energy like power lines, and the initial cost of all the equipment is costly. Additionally, wind turbines could potentially pose threats to flying animals and harm wildlife, as well as being visually and audibly unappealing to people.

Hydropower

Hydro energy relies on water to generate power by using the flow of water in bodies of water like streams and rivers. In 2022, hydropower energy became the second-largest source of electricity in the United States, contributing 6% of the nation's total electricity generation. According to the International Energy Agency (2021), “global hydropower capacity is set to increase by 17%, or 230 GW, between 2021 and 2030” (International Energy Agency, 2021). Hydropower presents many benefits, its main benefit is that it brings a reliable source of energy since water flow can actually be controlled to generate electricity on demand. Additionally, hydropower produces no direct emissions of greenhouse gasses, which contribute to a reduction in overall air pollution and help to slow down climate change. Dams and reservoirs that are built for hydropower also provide opportunities for other activities such as flood control and water supply. However, hydropower also presents several challenges. Dams and reservoirs that are built to control hydropower can actually displace many communities and wildlife populations, significantly harming local ecosystems. Additionally, changes in the water temperature and the flow can impact fish populations and other aquatic life. Furthermore, the costs of building these facilities are costly, and hydropower may affect water quality.

Solar

Solar power is another green source that uses the power of the sun to generate energy. According to the U.S. Department of Energy (2021), the use of solar energy is projected to increase from 3% to 40% of the electricity supply of the US by 2035 and 45% by 2050 (U.S. Department of Energy, 2021). Solar energy offers many different benefits to the environment. Like the other renewable energy sources, solar energy decreases the amount of carbon

emissions as well as air pollution which helps mitigate the effects of global warming and improve air quality. The use of solar energy systems can also mitigate the environmental impacts of energy production by decreasing the dependence on fossil fuels. Moreover, solar installations can provide ecosystem benefits like the creation of habitats for wildlife in solar panel fields. However, there are challenges associated with solar energy, including land use conflicts, as solar farms require lots and lots of space which can possibly impact ecosystems and farmlands. Additionally, producing and throwing away solar panels uses dangerous materials in the process.

Biomass

This renewable energy source uses materials like plant and animal waste to generate energy. Currently, the use of biomass is still in small amounts and biomass supplied only 1.2% of electricity in 2022 in the US. However, there will be a steady increase in biomass usage. In 2022, the United States generated approximately 4.84 quadrillion British thermal units (Btu) of energy from biomass. Additionally, the use of biomass is predicted to increase to 5.19 quadrillion Btu by 2050 (Statista, 2022). Biomass energy presents several advantages and challenges as a sustainable energy source. One of the primary benefits of biomass, like the other sources, is its ability to decrease dependence on fossil fuels, which in turn reduces greenhouse gas emissions and contributes to climate change prevention/mitigation. Furthermore, biomass can be sourced locally, which can provide new job opportunities. Additionally, biomass energy can be generated from waste materials, helping to reduce landfill use and manage agricultural and forestry residues. However, the challenges associated with biomass include the need for significant land and water resources to grow energy crops, which can compete with food production and impact biodiversity. The conversion processes for biomass energy can also produce air pollutants if not properly managed.

Geothermal

This energy source is collected from the heat stored within the Earth. In 2022, it has only supplied 0.4% of electricity in the US. However, in the future, By 2050, advancements in technology could increase geothermal energy production to at least 90 gigawatts in the US (U.S. Department of Energy, 2023). This source offers several advantages and faces unique challenges. One major benefit of geothermal energy is how it produces negligible amounts of carbon emissions and requires less land use, making it a green alternative ("Geothermal Energy and the Environment"). Additionally, geothermal plants can operate continuously regardless of weather conditions or time of day. However, geothermal energy also presents challenges. The extraction process can lead to land subsidence and localized environmental impacts, such as the potential for air and water pollution from trace elements like ammonia, methane, and carbon dioxide. There are also concerns about induced seismicity, where geothermal operations might trigger small earthquakes, which could potentially affect nearby communities or historical sites.

Conclusion

In conclusion, each renewable energy source presents pros and cons, contributing to the broader goal of reducing the use and dependence on fossil fuels and slowing down the effects of global warming. Solar and wind energy stand out for their significant potential to decrease carbon emissions and provisions of smaller solutions for electricity generation. Hydropower, while effective in providing reliable and consistent energy, faces challenges related to environmental impacts and high initial costs. Biomass offers a way to utilize organic waste and support rural economies, but there are land use and air pollution concerns. Geothermal energy, though currently a minor contributor to the energy mix, holds promise for significant future growth with minimal emissions and high reliability. The best solution will require balancing diverse energy sources, optimizing their benefits, and addressing their limitations through technological advancements. By integrating and improving these renewable energy sources, society can work towards a green energy future that meets global energy use while preserving environmental health.

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